EYE HEALTH
IN
INDUSTRY

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COMMISSION FOR THE BLIND AND VISUALLY HANDICAPPED
NEW YORK STATE DEPARTMENT OF SOCIAL SERVICES
15 Park Row, New York, N. Y. 10038

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FOREWORD

The State Commission for the Blind and Visually Handicapped of the New York State Department of Social Services has, for many years, been interested in protecting the health of the eyes of the workers in industry. With this in mind, a booklet, "The Eyes of Industry," by Leonard W. Jones, M.D., was first published in June, 1946.

With the passing of time, many advances have been made in the field of eye health and safety, both in knowledge and equipment. In this scientific and mechanical age in which we live, now more than ever before are the needs of good vision in demand, and perhaps the hazards of industry are at their greatest. Industry should not only utilize eyesight, but should also maintain, conserve, and protect it. Eyes that do not see well are a tremendous industrial handicap to their possessors, and they affect the welfare of the entire country.

Because there is a definite need for more and better ophthalmic service in industry, the State Commission for the Blind and Visually Handicapped is publishing this booklet as an up-to-date treatment of the subject. The information on the following pages has been prepared with the laymen in mind. It is intended for use primarily by smaller businesses and in factories which have no eye-safety programs at present; also by firms which have programs that may need to be revised, expanded and brought up to date. It should be read by employers, safety engineers, safety directors, industrial nurses, and all personnel responsible for health and safety. Its purpose is to act as a guide in the establishment or the continuation of an eye health and safety program. It may also be found useful in schools. Similar eye safety programs should be provided for students when they work where hazards exist: in chemical laboratories and in school woodworking and industrial arts shops.

ACKNOWLEDGMENTS

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WHY HAVE AN EYE PROGRAM?

This is an age of speed, precision, and machines. It is an age of vision, T.V., and 3-D. The burden of work has been lifted from men's backs, and placed on their eyes. There is increased need for skill, judgment, and timing based on visual perceptions.

Vision cannot be too good for a job, but it can be too bad for a job. There is a need to find and correct eye defects. Industry and its millions of employees have much to gain from eye testing procedures. The aim of industry should be to utilize, maintain, conserve, and protect the eyesight of all employees. The personnel department should be interested in proper placement; the safety department should be interested in reduction of accidents; and the production department should be interested in working efficiency. All these factors are dependent on the eyes and suitable vision.

Benefits of an eye program to the employer include:

- Increased production efficiency—quantity and quality
- Increased safety in plant operations and drop in accident rates
- Reduction in visual complaints
- Improved general morale
- Proper placement of new employees resulting in reduced training time and better job performance
- Decreased turnover in certain jobs
- Decreased absenteeism
- Large savings in money and lost time by decreasing the number of compensation claims
- Good employee relations
- Diminished costs of production resulting from less spoilage and wasted man hours

The result of all these factors is more profit for the employer, which is, after all, the reason for his being in business. The key factor is the ability of employees to see well enough to perform work tasks efficiently and safely.

Benefits of an eye program to the employee include:

- Knowledge that their vision is good for the job

- Knowledge that their eyes are protected against hazards of their jobs
- Increase in wages which will often come from increased production
- Reduction in eye fatigue
- Satisfaction which comes from better job performance
- Early detection of visual disorders through referral to doctor. (For instance, near vision skills deteriorate at a slow pace, so many people delay obtaining care.)
- Reduction in human suffering, by having available emergency first-aid care in case of injury to the eye

The employee will give full co-operation if it is shown that a preventive eye health program will be to his benefit.

The significant relationship between visual efficiency and production efficiency means that it is sound economy to use a systematic program of eye examinations to rehabilitate and maintain the visual efficiency of all employees. Any such program must be justified on the basis of economy to be practical. One only has to look at the results of those industries that have inaugurated and carried out comprehensive visual programs to prove that such programs show a large return for the amount of money invested, and that they meet and exceed all expectations.

Sperry Gyroscope Company reported on the first ten-year period of its program, 1944-1954, during which time they had employees numbering between 11,000 and 18,000. The cost of the program for the 10 years was $400 000. The year before the program was introduced six eyes were lost completely and there were 56 serious injuries resulting in partial loss of sight. In the 10 years of the program not one eye was lost or seriously injured. There was a 90% decrease in first-aid eye cases. There were 82 pairs of smashed safety glasses. which involves a saving, in a direct and indirect expense, of $1,680 000 if 82 eyes had been lost. Apart from this there was the great saving of human suffering for which there is no monetary evaluation.

The Cummins Engine Company of Columbus, Indiana, reported that, in the first three years of their program, they spent about $5,500 on eye protection and saved 33 eyes from blindness. Compensation for these eyes would have cost 20 times the amount spent on the program.

In the milling and heat treating department of Eastman Kodak Co. in 1952, there were 170 eye injuries. Their eye protection program was made more effective in 1953, and in 1954 there were only 10 injuries, and in 1955 only 11 injuries recorded. All of these eye injuries were minor in nature. There has been no major injury up to the present day.

Figures from many plants show that 90% of employees who have professional eye care as a result of a screening program can have their vision brought up to meet the standard for their jobs. A large percentage, who are below desirable standards of visual performance for their jobs, are unaware of it. In a plant in Illinois, when the program started, over 50% were found with substandard vision for their jobs. The percentage of accident-free workers is certainly higher among that group whose eyes are right for the job.

Industry should be interested in knowing not only how well the workers see, but also in how to adapt various capacities of eyesight to the work tasks of modern industry.

More attention should be given to the importance of job placement in relation to the individual's visual abilities. This results in increased production and also prevention of accidents. Pre-employment visual function tests should be considered to be in the interests of both the employer and employee. The employer is assured of knowing the fitness of the person to undertake the work; the employee has the safeguard of not being put on a job which may strain or even harm him. A person with one functioning eye would not be allowed to waste his time learning a job which needs stereoscopic vision, and he would probably be given a job in which there would be little danger to his good eye. A person unfit for one type of work is usually suitable for another type. After assessing the capabilities, a suitable job can be given in which the person is likely to succeed. It is obvious that a watch repairer or tool maker requires vision of a different nature than that of a janitor or a woman in a cafeteria. Also the girl who matches shades of buttons in a factory will need a sense of color that is unnecessary for a woman who sprays black lacquer on metal casings.

Any person is capable of working in industry, irrespective of his vision. Some industries even employ persons who are totally blind. The aim should be to place each man in a position where, if he has a visual defect, he will be able to perform his work effectively; he will not endanger his fellow workers; nor will he hamper his employer who must produce goods in quantity and at a cost to meet competition.

Information about a worker's ability to see at the time he was hired is extremely important when it comes to a compensation claim for work-connected visual loss. A company without accurate records of vision has little defense against being held responsible for loss of sight, despite the fact that the claimant's vision may well have been poor even prior to being employed.

To encourage the employer to hire a handicapped person, such as one with only one eye, there is a second injury fund administered by the Workmen's Compensation Board which relieves the employer of responsibility for total disability after two years. However, it is essential that there is an accurate record of this eye defect to be able to take advantage of this fund, otherwise the employer may be held responsible for a lifetime of disability.

As well as seeing if the eyes are right for the job, it is becoming more and more important to see that the job is right for the eyes. The study of lighting, brightness, magnification, and color engineering of the job to fit the capabilities of the worker can make the job easier and safer to see, and thus the quality of production is increased and accidents reduced. In industry the study of ergonomics, dealing with human factors in the design and operations of machines, is becoming important in making machines more to fit the man rather than having to adapt man to machines. This will lead to more safety in operations.

The objectives of a complete eye program are to make sure that the workers possess vision to meet the demands of their job, to protect their eyes against hazards of their job, and to provide eye care in case of injuries.

SIMPLE ANATOMY

The eye consists of three coats (Figure 1):

(1) *Outer coat or Sclera* — a hard white protective covering with a round transparent window in front, known as the *cornea.*

(2) *Middle coat or Uveal Tract* — a layer rich in pigment and blood vessels which carry the blood to nourish the eye. It consists of iris, ciliary body, and choroid. The front part, which is visible through the cornea, is called the *iris.* This is what we are looking at when we see the color of the eye. The round opening in the middle of the iris is the *pupil.* The pupil allows light to pass through the eye to the inner coat.

(3) *Inner coat or Retina* — a light sensitive nerve layer from which the fibers of the optic nerve convey messages to the brain. The small area at the back of the retina, which enables one to see clearly, is called the *macula.*

A watery fluid, aqueous humor, fills the space between cornea and lens. Behind the lens the cavity is filled by a transparent gel, the vitreous humor.

Covering the front part of the sclera and the back surface of the lids is a thin transparent membrane called the *conjunctiva.*

The eye is contained in the bony orbit of the skull, and is moved by means of co-ordinated actions of six extraocular muscles which originate in the orbit and are inserted into the sclera. The muscles are called medial rectus, lacteral rectus, superior rectus, inferior rectus, superior oblique and inferior oblique (Figure 2).

FUNCTIONS OF THE EYES AND HOW THEY ARE TESTED

The eye is like a camera. It focuses light rays on the retina where they are converted into electrical impulses. The optic nerve then conducts these impulses to the brain where they become translated into conscious vision. The functions of the eye include distance vision, near vision, fields of vision, binocular vision, and color vision. Visual acuity is a test of function of the macula.

DISTANCE VISION

This is the ability to see the test chart or letters at 20 feet. Seeing is a complex act combining several skills, and the distance visual acuity is only one of these skills. Many times this function of the eye alone is evaluated by industry and little attention is paid to the other functions, which in many ways are just as important. The test should be performed on each eye without glasses and also with glasses if they are worn.

The term 20/20 is not a fraction but simply means that a person sees at 20 feet what he ought to see at 20 feet. The term 20/40 does not mean a 50% loss of vision, but that the person sees at 20 feet what a normal eye would see at 40 feet. The numerator indicates how far the person is away from the chart and the denominator indicates the distance at which a normal eye would be able to distinguish the letter. The New York State requirement for driving is that the person has at least 20/40 vision. A visual acquity projector is the best method for testing distance vision (Figure 3). If this is not available, a Snellen wall chart may be used.

Illumination of the chart should be about 20 foot candles. To fit a room less than 20 feet in length, the size of the "200" letter in inches should be: distance of patient to chart in feet x 0.174.

If the "200" letter cannot be identified at 3 feet (3/200), vision is recorded as the ability to count the examiner's fingers at certain distances. If this cannot be seen, the vision should be recorded as hand movements. Failing this, the ability to see light should be tested. An eye should only be considered totally blind when there is no light perception present.

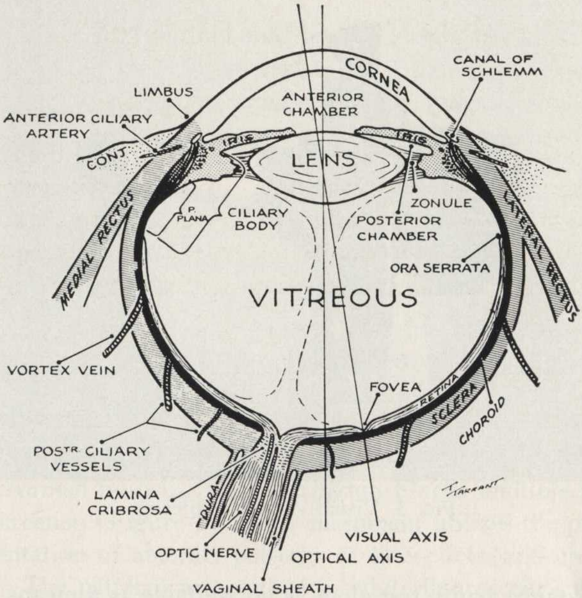
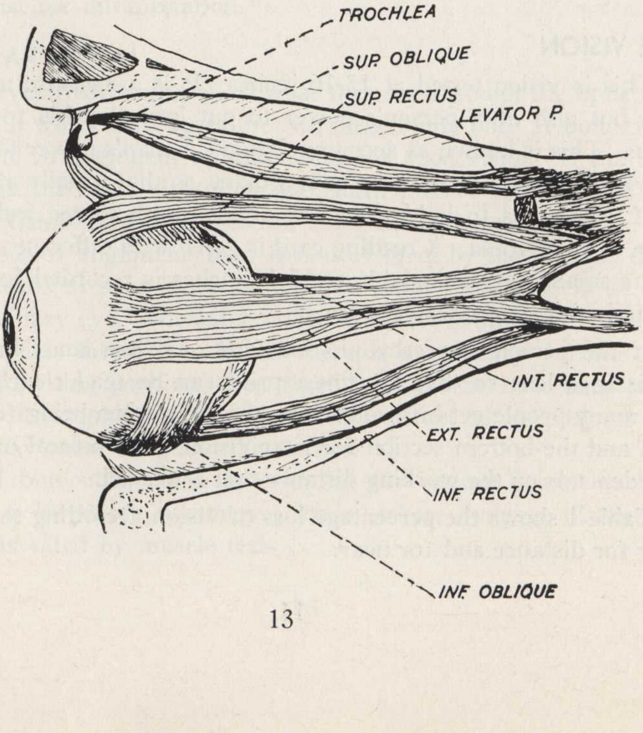


FIG. 1. *(Above)* — The Eye in Cross Section

FIG. 2. *(Below)* — The Eye Muscles



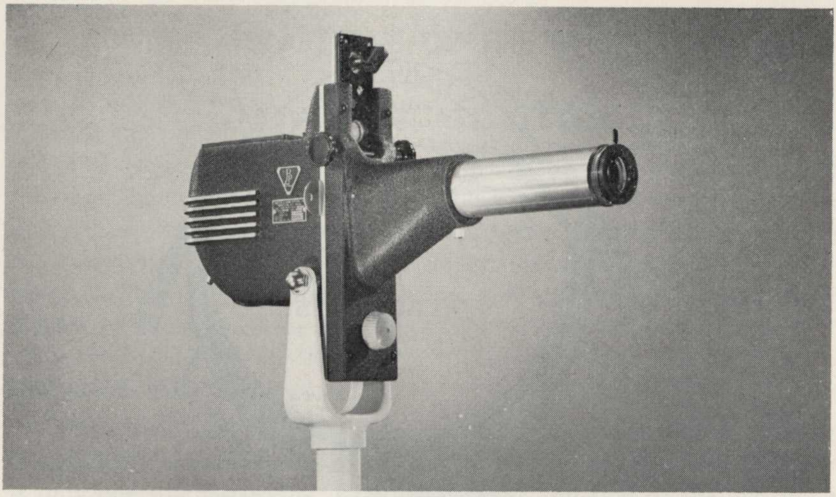


Fig. 3. Visual Acuity Projector

The distance acuity test alone is not suitable as a means of allocating employees to jobs that call for close vision, because their distance vision may be poor, but their near vision very adequate for the job and vice versa.

NEAR VISION

This is vision tested at 13-16 inches. It is a measure not only of vision but also of a person's power to put into play his focusing apparatus. This is known as accommodation. A man's power to focus for near vision becomes less as he grows older, so that usually at about the age of 45 he has to hold things at arms' length to see well. This is known as presbyopia. A reading card is given with different sized print, and the smaller print readable at 13-16 inches is recorded for each eye with and without glasses (Figure 4).

If the person is presbyopic, an additional lens must be added to the distance lens so that the finest print can be read clearly. This is when many people get bifocal glasses, the top section being for distance vision and the bottom section for near vision. The bifocal or near lens given depends on the working distance that is needed.

Table I shows the percentage loss of vision according to the visual acuity for distance and for near.

FIELDS OF VISION

This measures the peripheral or side vision, or the area which a person sees. It is a measure of the health of the retina. A normal field enables a truck driver to see things coming from the side while he is looking straight ahead. A normal field aids an employee to avoid running into doorways or projecting posts or other people passing by. Tangent screens and perimeters are used by doctors to test the field accurately, but it can be done roughly as follows:

The person to be tested faces the examiner, and covers his right eye and looks at the examiner's right eye with his uncovered left eye. The examiner covers his left eye and puts his fingers up in different positions at an equal distance between the two uncovered eyes. If there is a blind area, the person will miss counting the fingers in this area. This is called a field of confrontation.

In industry, a good rapid screening device for central field defects can be performed by using the Harrington-Flocks multiple pattern visual field screener (Figure 5). This insrument utilizes the principles of flash presentation of abstract patterns of lines, dots, and crosses to the fixing eye. The patterns are printed in white fluorescent sulfide ink on white cards and can only be seen when illuminated by a ¼ second flash of ultraviolet light. The patient indicates what he has seen and errors are checked off on a chart. Any defect should be referred to the ophthalmologist for interpretation.

BINOCULAR VISION

The eyes relay impulses of what they see through the optic nerves to the brain which then fuses the two images into one. If both eyes are healthy and in alignment an individual has good vision. If the images relayed are the same size, then one sharp picture is seen, and this is binocular vision. If the images are different in size or clearness, or the eyes are out of alignment, then fusion of them by the brain is difficult and this leads to poor binocular vision — sometimes evident as double vision or a lazy eye. Normally, when an object is observed, the macula of each eye is directed to it. If there is a tendency for one eye to deviate from this position, then there is a muscle imbalance present, known as heterophoria. The unconscious effort of keeping an eye in position may cause fatigue or headaches.

Good binocular vision is essential for certain jobs — such as a pilot, or a carpenter hammering nails, where judging distances are vital. It is rated by muscle tests.

The power to converge is tested. If a person cannot turn in his eyes to at least eight centimeters from the nose he is apt to tire easily at prolonged close work.

The most important test, the muscle balance test, measures the relationship of the image of each eye to that of its fellow. It is performed both at distance and near for both horizontal and vertical imbalances. There are several ways of measuring for this. One common way is by using a lens called a Maddox rod (Figure 6). This is a lens which produces a fine line when a point of light is looked at through it. Thus, the images of the two eyes can be separated.

For instance, to test the muscles that move the eyes in or out, the lens is held in front of the right eye so that the line seen is vertical through the right eye when looking at a spot of light with the left eye. If the line goes through the light, the eyes are straight (orthophoria). If the line is to the right of the light then the eyes have a tendency to turn in (esophoria). If the line is to the left of the light, then the eyes have a tendency to turn out (exophoria). By putting up a prism in front of the eye, with base out in esophoria or base in in exophoria, the light can be made to touch the line. This is then a measure of the imbalance.

Similarly, the muscles that move the eyes up and down can be tested by turning the Maddox rod so that the line is horizontal. Then the light is viewed and it can be seen whether the line is passing through the light (orthophoria), or is above (left hyperphoria), or below (right hyperphoria). A left hyperphoria can be measured by putting up prisms base up in front of the right eye, and a right hyperphoria can be measured by putting up prisms base down in front of the right eye.

A certain amount of phoria is consistent with good binocular vision. However, phorias may lead to much eye strain and headache, and even to double vision or lack of binocular vision. This will have to be determined by the eye doctor on an individual basis.

The highest standard of binocular vision is depth perception or stereopsis. This is the ability of the eyes to judge relationship of objects in space. Persons with poor binocular vision should not be put on jobs that demand judgment of distance such as punch presses, lathes, hand drills, and the like. However, practice frequently enables workers to overcome the deficiencies of binocular vision especially in a repetitive task. A person who has lost binocular vision may rapidly acquire

Acuity Rating **Visual Efficiency**

14/14 **100%**

Certain weather forecasters have used an official scale in which winds are defined in terms of their rates of speed. When the velocity is less than one mile an hour, the term "calm" is used. A "light" wind travels at the rate of one to seven miles an hour. Eight to twelve mile an hour winds are called "gentle." "Moderate" winds travel at the rate of thirteen to eighteen miles an hour. "Fresh" winds have a higher velocity of nineteen to twenty-four miles per hour.

14/21 **91.5%**

Winds traveling twenty-five to thirty-eight miles an hour are termed "strong." When a speed of thirty-nine to fifty-four miles an hour is reached, the term "gale" is used. "Whole gale" describes winds having velocities of fifty-five to seventy-five miles per hour. When wind velocity exceeds seventy-five miles an hour, the term "hurricane" is used.

14/24.5 **87.5%**

Two items of information are required for making weather forecasts—the direction and rate of change of atmospheric pressure, and the direction of the wind. Atmospheric pressure is measured on the barometer. A high and steady barometer indicates fair weather and little temperature change.

14/28 **83.6%**

A rapidly falling barometer always indicates increasing wind. In association with a low reading, a rapid fall indicates approaching storms. When the wind is east to north, northeast gales with heavy rain or snow are to be expected. In winter, a cold wave usually follows.

14/35 **76.5%**

If the barometer is high and is falling slowly, different forecasts are made according to the direction of the wind. When the wind is south to southeast, rain is expected within twelve to eighteen hours.

14/42 **69.9%**

When the wind is east to northeast, with a high barometer falling slowly, light winds and fair weather are expected in summer, but in winter this means rain in twenty-four hours.

14/56 **58.5%**

Winds near low pressure areas shift in a counterclockwise direction; near high pressure areas they shift in a clockwise direction.

14/84 **40.9%**

Clearing weather accompanies changes from low to high pressure.

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FIG. 4. Reading Card

facility in the use of monocular clues — perspective, overlapping, shadows, and size contrasts. These experienced workers may do their job better than a less experienced worker with perfect binocular vision.

COLOR VISION

This is not a problem in many industries, and if so the test need not be performed. Many people are partially color blind, and it is no handicap to them in their work as the rest of their eyes are perfectly normal. About 4%-8% of the male population have some red-green blindness.

To test for color vision, special charts are used in a book, in which patterns (usually numbers) are made up of dots of the primary colors printed on a background of similar dots in a confusion of colors. The patterns are read correctly if the color vision is normal and incorrectly or not seen at all if the color vision is deficient. The charts are called Ishihara charts or pseudo-isochromatic plates, the latter a product of the American Optical Company (Figure 7).

BATTERY VISION TESTING

There are several instruments which have been developed to test many visual functions such as those just described. Those in use are the Bausch and Lomb Ortho-rater, American Optical Sight Screener, Keystone Telebinocular and the Titmus Vision Tester. The tests are so designed that they can be given by a trained layman or nurse in about 5-7 minutes.

The Ortho-rater is illustrated as an example (Figures 8, 9, 10). It tests the distance and near vision of each eye separately and of both eyes together, distance and near lateral and vertical phorias, depth perception and color vision. Ratings are recorded by marking the findings on a special visual performance card. This can then be compared with the normal standard profile for a particular job (Figure 11). The instrument is very useful in that it is portable and can be used where space is limited, and also the illumination is constant.

These battery testing devices must be used with a clear knowledge of their limitations. They are not diagnostic instruments. They record visual skills only, and cannot give a diagnosis nor can they replace a doctor's examination. They are designed to complement and not replace the work of the eye doctor. They point the way to suitable job performance, and lead the way to the doctor for timely corrective pro-

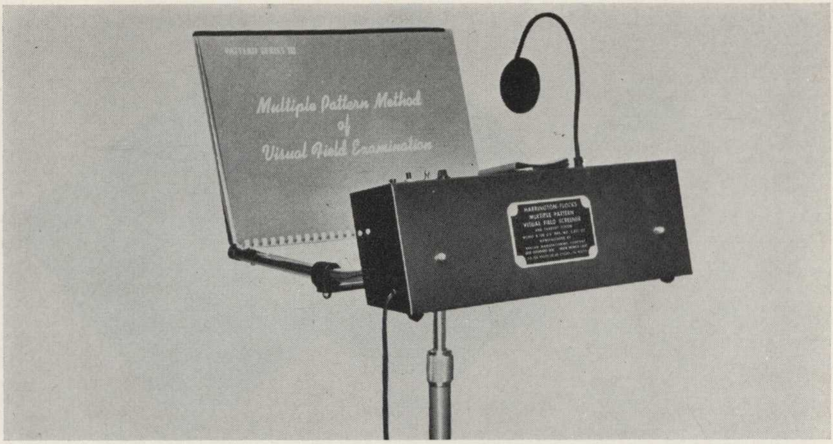
Multiple Pattern Method of Visual Field Examination
HARRINGTON-FLOCKS MULTIPLE PATTERN VISUAL FIELD SCREENER

FIG. 5. Harrington-Flocks Multiple Pattern Visual Field Screener

cedure. The success of these tests is dependent on a competent person to operate the instrument, and also on a doctor to analyze and interpret the results.

Every case with tests below par should be referred for a professional eye examination. A professional examination will include all of the above-mentioned skills plus a careful examination of the external and internal features of the eye to see if there are any abnormal conditions present, and a refraction to see if glasses are needed. Only then can an opinion be expressed as to the applicant's or worker's suitability to a job. It is also important to have this prior knowledge for any subsequent charge the employee may have on the company. Eyesight is not static and periodic retesting should be scheduled.

The eye program should not be considered by employees as a weeding out procedure, but one of correction and protection. The tests are not made to bar the employees, but to place them where they will perform most efficiently.

LIGHTING

Adequate illumination and adequate vision are not synonymous, but they supplement one another. Each is a necessary ingredient in the task of seeing efficiently. Improved lighting often brings latent visual problems to the surface. Lack of good lighting results in lowered output, spoiled work and loss of working time through fatigue and accidents.

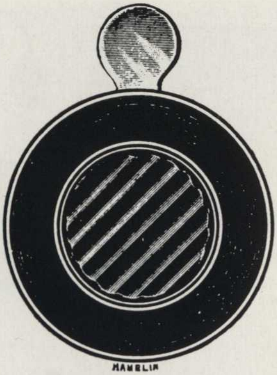

FIG. 6. Maddox Rod

Even with perfect eyesight it is impossible to see without light. Thus, in developing eye programs, it is also important to consider the light problems for each particular job. The amount of light needed to see adequately varies with the job, and it is extremely important that work areas are properly and adequately illuminated. The quality of the light must also be good so that glare and shadows are reduced to a minimum. The local utility company will usually provide the services of illumination specialists without charge. There are standards, and these are available from the Illuminating Engineering Society, 345 East 47th St., New York, N. Y. 10017.

Color is also an important factor. Dark surroundings should be avoided. Background contrast is important, e.g., a white thread against a white background is almost invisible in any light, but against a dark background it stands out clearly. The greater the contrast, the easier the task of seeing.

EYE HAZARDS IN INDUSTRY

The possible causes of injury to the eyes are legion. It is impossible to foresee everything that might happen, but it is possible to prevent most accidents. It is much less costly for management to prevent accidents than to pay the cost of damages after they have happened.

The commoner eye hazards are mechanical, chemical, and physical. They include:

- Contusion from a fall, blow on the eye, or explosion

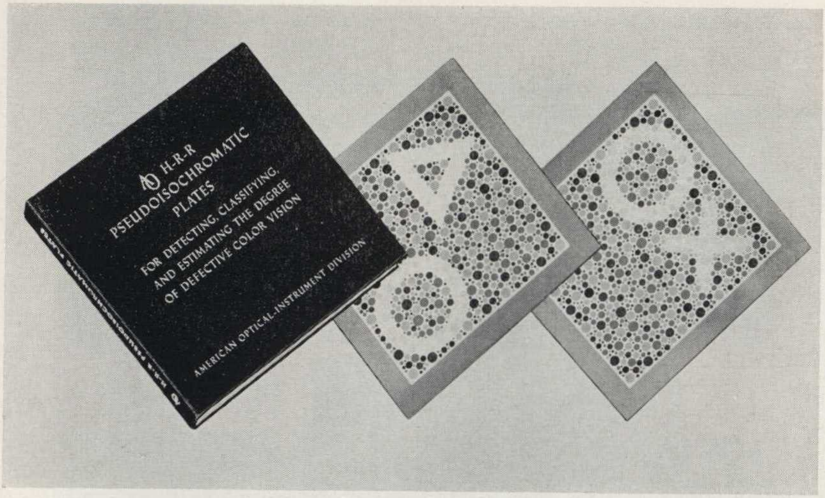
AO H-R-R
PSEUDOISOCHROMATIC
PLATES
FOR DETECTING, CLASSIFYING,
AND ESTIMATING THE DEGREE
OF DEFECTIVE COLOR VISION
AMERICAN OPTICAL-INSTRUMENT DIVISION

FIG. 7. Color Vision Plates

- Large or small flying objects. Metal workers probably are the most prone to eye accidents, and are frequently struck by chips of metal from worn or poor quality tools, or grinding wheels. Tools with "mushroomed" heads must be eliminated or the condition corrected.
- Dust and powders
- Splashing molten metal
- Chemicals; not only liquids and solids, but vapors and gases also. Chemical hazards may be acute, such as when an acid or alkali splashes into the eye causing an immediate effect requiring emergency care; or chronic, such as in workers exposed to vapors of quinone and dust of hydroquinone who may develop corneal and conjunctival injury gradually over a period of years, and workers with naphthalene and dinitrophenols who may gradually develop cataracts.
  Workers with lead may develop lead poisoning which can cause damage to the eye muscles and optic nerve, as well as to other parts of the body.
- Radiation effects. A risk for overexposure to a variety of radiations capable of causing eye injury is presented by numerous occupations and operations such as welding, glass and

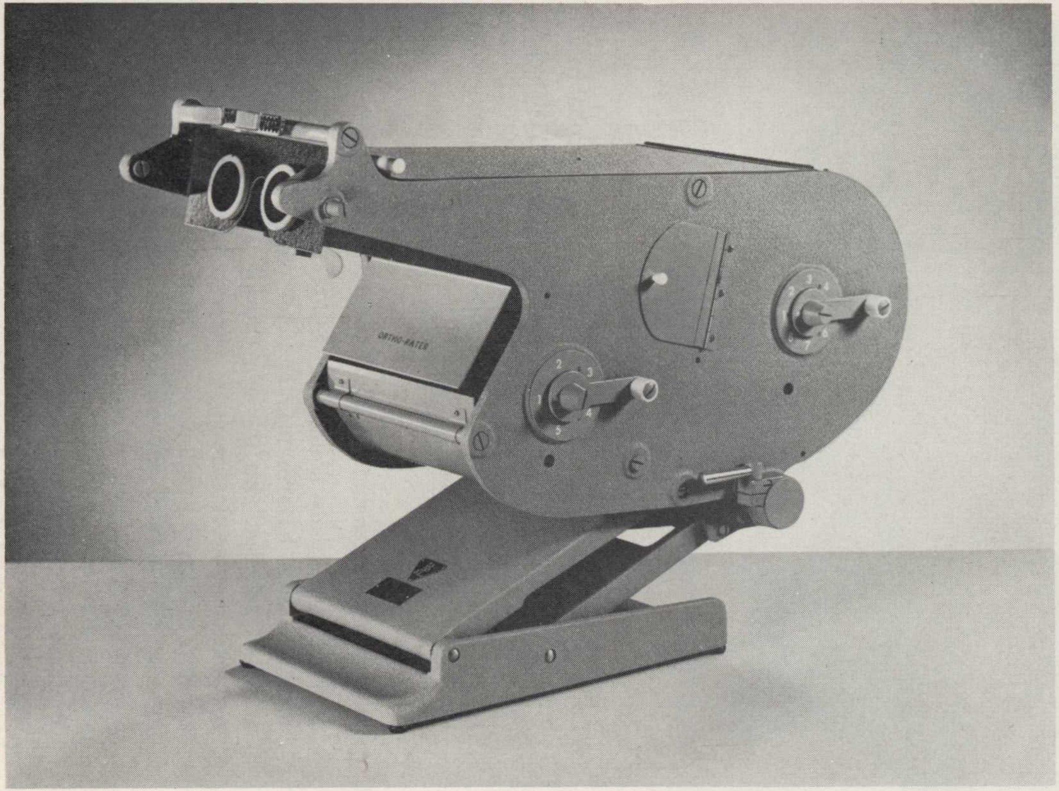

FIG. 8. Ortho-rater

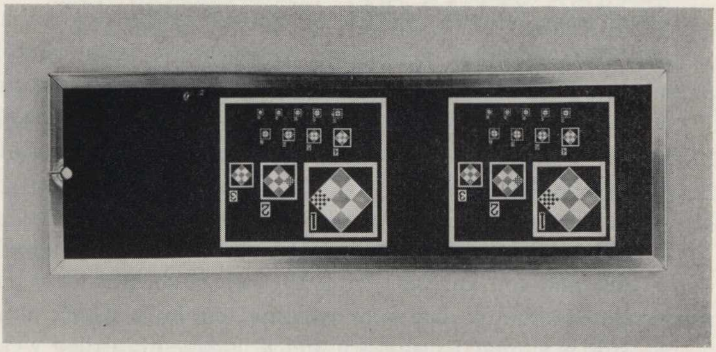

FIG. 9. Visual Acuity Slide for Ortho-rater

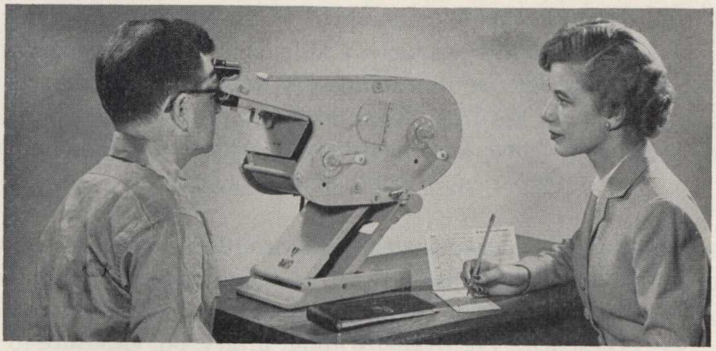

FIG. 10. Ortho-rater in use

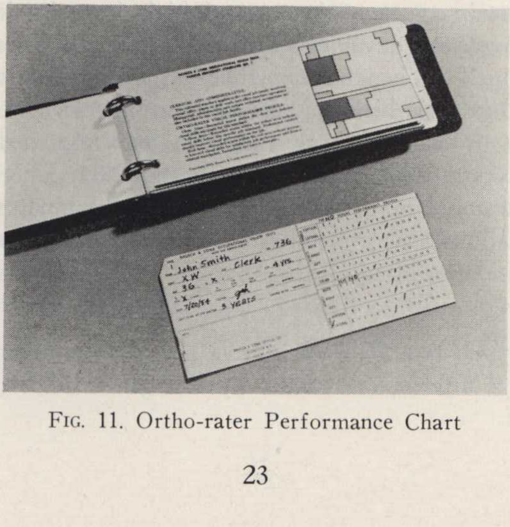

FIG. 11. Ortho-rater Performance Chart

metal furnace work, the use of sources of ionizing radiation, and the operation of particle accelerators, radar and laser equipment. The effects produced are dependent on the intensity of the radiation, the duration of exposure, the type of radiant energy, and the part of the eye in which most of the energy is absorbed.

1. When absorption occurs in the superficial layers (the cornea and conjunctiva), as is the case with ultraviolet radiation from UV lamps or welding, the burn which may result is similar to sunburn and is frequently called welder's flash.

2. If absorption is predominant in the lens as with some types of high energy particles and ionizing radiation, microwaves from radar and some infrared wavelengths, cataracts may form in the lens. These lens opacities may interfere with vision or may only be detectable by instrument examination by an experienced ophthalmologist.

3. Radiant energy which is transmitted through the cornea and lens but absorbed in the retina and choroid, as is the case with visible light, may cause glare and symptoms (headache, eye strain) without injury, but exposure to very high intensities can cause retinal burns and permanent injury. This has occurred with exposure to radiation from certain types of lasers and high intensity lamps. Lasers have been developed to treat certain conditions of the eye which can benefit from such burns. The intensity and duration of the beam is kept under very strict medical control. In order to prevent radiation injuries, workers in these tasks must be protected with absorptive lenses specific for the job. The correct absorptive lens eliminates harmful radiations and transmits the visible light rays necessary for vision.

It is estimated that 70% of all eye injuries are occupational, and that 90% of eye injuries are caused by foreign bodies, wounds, burns, and contusions.

EYE PROTECTION AND SAFETY DEVICES

"An ounce of prevention is worth a pound of cure" can be truly said when discussing eye safety, because the most effective method of dealing with accidents to the eyes is to prevent their happening. Many accidents can be attributed to insufficient instruction in safety procedures, fatigue of the worker, or taking chances. Eye protection is usually achieved by three general approaches which are frequently used in combination.

1. Control of the hazard at the source, such as by shielding or enclosing radiant sources, handling chemicals in closed or automatic systems or with local control ventilation, providing transparent screens for mechanical operations, and elimination of unsafe tools.

2. Eye protection for the individual through use of his personal safety glasses, goggles or face shields or by use of special eye protection designed for specific hazards such as welding or laser operation.

3. Careful instruction of workers in safe procedures and encouragement of their active participation in the eye safety program and in the development and use of standard safe practices.

Figures 12-17 show some of the varieties of safety devices that are worn. It is not safe to use just tinted glasses, which reduce transmission of visible rays, if there is danger of ultraviolet and infrared radiation. Employees who work at jobs that might in any way be dangerous should be provided with safety glasses. These glasses must be worn all the time when the worker is in an area where eye hazards exist. Industrial safety lenses must resist the impact of a ⅞″ diameter steel ball weighing 1.56 ounces dropped 50 inches onto the horizontal upper surface of the lens. Safety frames are flame resistant and are designed to retain the safety lenses under heavy impact.

An industry with eye hazards which permits plant use of ordinary street glasses jeopardizes the eyesight of its employees and possibly its own legal position. The indiscriminate use of safety glasses without consideration to the basic seeing abilities should be discouraged however.

Full information about industrial safety eyewear is given in the American Standard Safety Code for Head, Eye and Respiratory Protection Z2.1-1959 which can be obtained from the American Standards Association, 10 East 40th St., New York, N. Y. 10016.

The protection of the eyes of workers must not be confined to the provision of safety glasses alone. Much thought and direction must also be given to such items as screens on machinery, illumination, ventilation, and good quality tools; plus, of course, the selection of the right worker for the particular task.

Chemists and technicians should be given instruction in the safe handling of mixtures which may be explosive or may splash. Chemical hazards should be eliminated by such things as substituting nonhazardous chemicals, if possible, and checking for leaky valves, joints, pipes, and tanks. Educate the workers to be careful in removing stoppers, opening tanks, etc. There should be exhaust hoods on equipment where needed. Proper ventilation, showers, and eye irrigating fountains should be provided for the workers. Eye shields must be worn where necessary. Human exposure can sometimes be reduced by mechanizing the handling of chemicals. Projecting rods and beams and other such obstacles around the plant either should be eliminated or marked in some way so they become very conspicuous.

A safety supervisor should be appointed in every factory, even when the scope of personnel is limited in numbers and ability. Someone must also be responsible to maintain the safety apparatus. There should be an educational program to explain the need of eye safety devices to the workers. It has been estimated that, of more than 300,000 eye accidents occurring in industry each year, more than 90% of them could have been prevented.

The National Society for the Prevention of Blindness, Inc., has sponsored an eye safety incentive plan since 1948. This is known as the Wise Owl Club. It has proven most effective in industrial eye protection and conservation of sight. Membership is restricted to industrial workers whose sight has been saved because of wearing eye protection when an on-the-job accident occurred. Club membership is over 38,400 in 4,900 chapters in the United States and Canada. These chapters are in plants that employ more than 6 million workers. So one can see the enormous savings both in human suffering and in economic loss due to such eye safety programs. There has been a saving of about 192 million dollars in compensation alone from these preventable injuries.

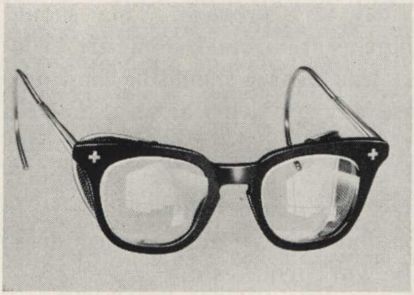

FIG. 12. Safety glasses with side shields for operators of tools, machinery and grinders

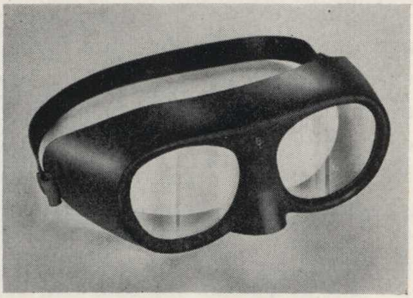

FIG. 15. Goggles for chemical workers

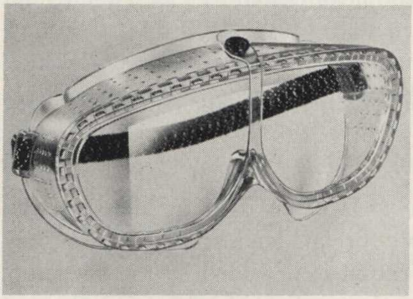

FIG. 13. Eye Shield Goggles for woodworking, chipping, and compressed air

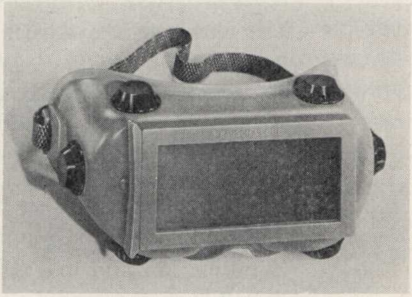

FIG. 16. Welder's Plate Holder. The plates are available in many shades

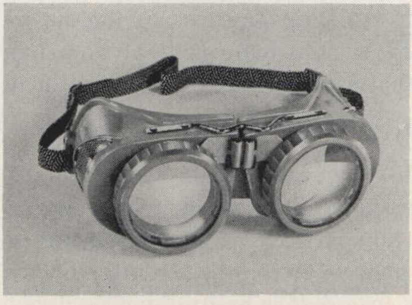

FIG. 14. Coverall Goggles with filtered lenses—for welders, furnace workers with molten metal

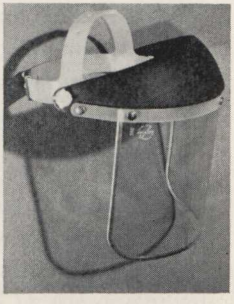

FIG. 17. Flip-up Face Shield

The wearing of contact lenses may be a problem. They should not be worn where dust and flying objects are around, or where exposure to chemicals is great. A contact lens wearer should be known to the plant medical department in case any problems arise. Should a chemical get in the eye, the contact lens should be removed immediately before any irrigation is started. Also the prescription for regular glasses should be known and all contact lens wearers should have regular glasses to wear should the occasion arise — and it often does! Safety lenses must still be worn if the work requires it.

FIRST AID EQUIPMENT

The minimum requirements are as follows:

- Visual charts for distance and near vision
- Chair with a firm headrest
- Adequate illumination

  A small pocket flashlight which can focus a beam of light is all that is needed.
- Adequate magnification

  A binocular loupe, such as is often used in industry, can be used to help see small foreign bodies, etc. The best in illumination and magnification is provided by the slit lamp, but this is an expensive and complicated piece of equipment which can only be used by a trained nurse or doctor.
- An eye irrigator full of normal saline, so that the eye can be flushed out with a fine spray
- Fluorescein strips

  Fluorescein has the ability to stain any loss of the superficial surface of the cornea, such as happens in an abrasion. The staining is green so that it can be more easily identified.
- Cotton applicators
- Eye pads
- "Scotch" tape or adhesive tape
- Drugs

There are literally hundreds of eye drops and ointments in use, and the drugs in every plant will vary depending on the personal preference of the physician in charge. If there is no physician or nurse available at the plant then no drugs should be stocked at all, except for a local anesthetic, such as ophthaine or ophthetic, and an antibacterial such as sodium sulphacetamide 10% drops and ointment. The use of these by lay personnel should be spelled out in the standing orders. If a registered nurse is employed, or a doctor comes to the plant, then certain other drugs may be made available. These would include pupil dilators, pupil constrictors, antibiotics, and steroids.

It should be left up to the medical doctor in charge to decide what drugs to have in stock and what not to have. These drugs should be reviewed from year to year as there are constant changes going on, and some drugs may become obsolete in time as new ones are introduced to take their place.

Around the plant at various strategic points there should be sources of water which can be used on the spot as a first-aid measure. There are commercial eye irrigating units available, but showers, jet drinking fountains, and buckets of water or hoses may be used. This is of particular importance when any chemicals, acids, or alkalis get into the eye. Employees exposed to chemicals should be informed of these water outlets and the reasons for them. Effective emergency eye wash stations can be put together in the plant. One such unit consists of a quick opening lever on a pressure reducing valve, which leads a large volume of water with a low pressure flow to a large diameter tube (Figure 18). This large volume of water under a controlled pressure is ideal for flushing out the eye.

First aid measures include:

- prevention of further injury
- removal of injurious agent
- improving comfort of the patient
- referral to the doctor if indicated

COMMON INJURIES AND THEIR TREATMENT

There should be standing orders set up by the doctor as to procedure to be followed by nurses or lay personnel doing first aid. The orders should define what should be done, what drugs may be used, what treatment may be given, and what should be referred to the eye doctor. These orders should also be reviewed by the doctor from time to time. Every injury must be recorded, and details such as name of patient, place, date, time of injury, how it happened, nature of injury, vision and treatment given must be put down in writing. The treatment will, of course, depend on the facilities that are available. Factories that employ trained nurses or physicians should send the injured directly to them. There it is decided whether the injury can be satisfactorily treated at the plant or should be referred to an outside ophthalmologist. The nurse should undertake only such treatment as is within the limits of her ability and accepted nursing practice. The case should be followed until cure is complete and then a final vision should be recorded. Should trained personnel not be available, the safest thing to do would be to apply a sterile patch to the eye and refer the patient to the consulting doctor. Whenever there has been a chemical injury, however, the eye should be thoroughly flushed out with water immediately for at least ten minutes before applying the patch. Factories that are too small to have a trained nurse or doctor at the plant should at least have someone trained in first aid so that initial treatment can be performed. Also, every factory should have an arrangement with an ophthalmologist in the nearest community so that they can call upon him when the need arises. The following treatments for common injuries are suggested if there are no standing orders available:

1. ABRASIONS OF THE CORNEA

Large abrasions are very evident; small ones may be more easily detected as green after staining the eye with fluorescein. Instill sulphacetamide ointment and patch the eye. Sometimes the patch is worn for 24–48 hours, sometimes the ointment alone is used every few hours. Often healing is rapid if the abrasion is not deep and if no infection occurs. Follow the patient daily until the eye is healed. If in doubt, consult the doctor.

2. FOREIGN BODIES

These may lodge under the upper lid. Always turn the upper lid over an applicator and if a foreign body is seen on the surface it can easily be wiped off the lid with the applicator. A bactericide such as sulphacetamide may be instilled. All such solutions used should be scrupulously free of contamination.

More often, the foreign body will lodge in the cornea. If so, instill a local anesthetic two or three times and then apply a fine spray of saline from the irrigator on to the foreign body. Many of them are dislodged and flushed out this way. A bactericide may be instilled.

If the foreign body is lodged in deeper, an attempt can be made to wipe it off with a moist applicator. If this fails, put in sulphacetamide drops, patch the eye, and refer the patient to the doctor who will have to remove it with an instrument under a slip lamp. A perforating foreign body is an extreme emergency. Patch the eye, keep the patient as quiet as possible and refer to the local ophthalmologist.

3. CHEMICAL INJURIES

Alkalis are more dangerous than acids because they continue to penetrate the cornea whereas acids do not. No time should be wasted, not even time spent getting to the first-aid station. The eye should be immediately flushed with the nearest tap water. The loss of a minute before the chemical is washed out may mean the eventual loss of vision. Run the water into the open eye if possible, or immerse the open eye into a bucket of water. Flush the eye for at least ten minutes. Then the eye should be inspected at the dispensary. An anesthetic should be instilled and the eye flushed out again with the irrigator. Any pieces of foreign material seen should be wiped away with an applicator. Make sure the undersurface of the upper lid is free of any particle. Instill sulphacetamide drops, put on a patch, and have the doctor see the eye without delay. These injuries can be very severe and disastrous.

4. BLOW TO THE EYE OR CONTUSION INJURY

This often causes marked swelling of the lids due to hemorrhage (black eye) and often hemorrhage under the conjunctiva. These alone are not serious, but if there is also hemorrhage within the eye then it becomes a serious problem. Other serious damage may have also been caused, such as dislocated lens, rupture of the globe, and prolapse of the iris. If the pupil is irregular in shape, the vision is blurred, and there is a history of a flying object, then there may be a foreign body imbedded within the eye. An X-ray will have to be taken and the foreign body removed in the hospital by surgery. In all these cases do nothing but patch the eye, and refer to the doctor without delay. A possible fracture of the orbit must also be considered.

5. WELDING FLASH BURNS

Anyone exposed to welding under 20 yards away should be protected by safety goggles. The reaction is usually delayed about 4–6 hours and then the eye begins to be very painful and sensitive to light. The condition usually clears within a few days. Cold compresses, sedatives, and antibiotic-steroid drops have proven useful in the treatment.

HOW TO SET UP A PROGRAM

- Obtain management approval for a program.
- Arrange for a suitable location for visual testing and emergency eye care.
- Have a responsible person in charge of the safety aspects of the program, such as a safety engineer. All procedures should be known by the consulting ophthalmologist where possible, and approved by him.
- Have someone trained to test vision, muscle balance, etc.
- Do visual tests on every employee to determine those in need of further care. Repeat periodically.
- Establish a referral policy with a local ophthalmologist, or, better still, arrange for the doctor to come to the plant on a part-time basis. The doctor should set up the method of testing, decide on drugs to stock, and have standing orders regarding treatment and follow-up care.
- Establish a method of having refractions and glasses prescribed.
- Provide safety glasses and other safety devices where possible.
- Have an education program which will inform all employees of the plan and its objectives. This may be done by using notice boards, exhibiting posters, distributing leaflets such as a safety newsletter, having articles in plant papers, having lectures and films on the subject, and having demonstrations such as a hammer pounding on safety glasses to show their resistance to breakage (Figure 19). Every worker should receive some training in accident prevention.
- Evaluate results in terms of the needs of particular jobs. A job analysis would include a knowledge of the working distance, working position, type of visual attention needed, colors to be seen, illumination, background contrast, type of working surface, possible eye hazards, and type of eye protection needed.

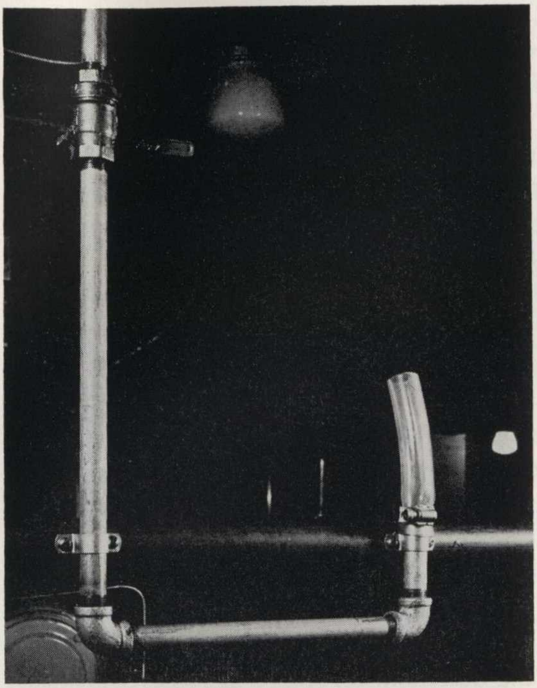

FIG. 18. Emergency Eye Wash Station

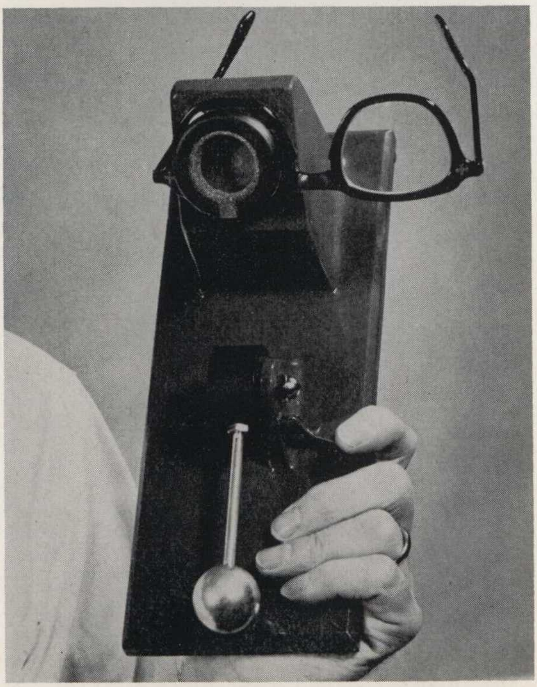

FIG. 19. Bal-Safe Impact Demonstrator. The steel ball wacks into the safety lens, and simulates the impact of 1⅛″ steel ball dropped 50″.

- Keep accurate records.
- Schedule periodic retesting.
- Do visual tests on all new applicants for placement evaluation, and also on those who transfer to new jobs.
- Check on proper safety devices on plant machinery, and protective equipment for each job. Try to eliminate any visual hazards in the plant.
- Insist that workers wear safety devices where needed. Visitors must also abide by the same rules.
- Provide optical aids such as magnifiers and loupes where needed.
- Lighting and color contrast should be checked at all work stations for their adequacy.
- Provide a service to adjust, fit, and maintain protective eyewear.
- Encourage useful ideas by employees on how to improve the program and safety measures by using employee suggestion boxes.
- Stimulate glaucoma detection, especially in plants with many older workers. All people over 30, and certainly 40, should have their eye pressure measured by the doctor by means of an instrument called a tonometer. About 2% of the population over the age of 40 have glaucoma.

Perhaps not all of the above services can be provided in the smaller factories, but the more that can be put into effect, the better the service will be.

TABLE I

ESTIMATION OF PERCENTAGE VISUAL LOSS ACCORDING TO VISUAL ACUITY

This should be done wearing the best possible corrective glasses

Distance Vision	*% Loss*	*Near Vision*	*% Loss*
20/20	0	J1	0
20/25	5	J2	0
20/30	9	J3	10
20/40	15	J6	50
20/50	25	J7	60
20/60	30	J11	85
20/80	40	J14	95
20/100	50		
20/160	70		
20/200	80		
20/400	90		

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